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**Energy Dynamics Dry Lab**

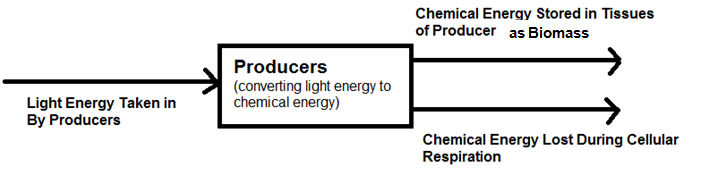
AP Biology, Mrs. Krouse and Ms. Glick, 2015-2016

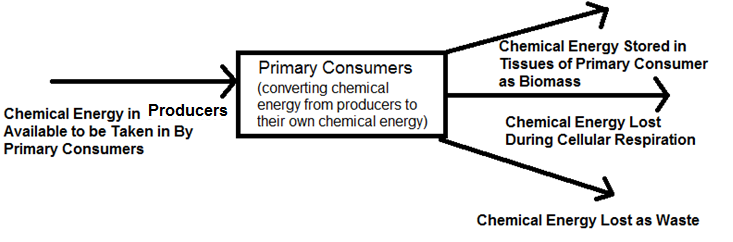
**Learning Objectives**

* To explain community/ecosystem energy dynamics, including energy flow, net primary productivity (NPP), and primary and secondary producers/consumers
* To demonstrate understanding of mathematical analyses in energy accounting and community modeling by calculating biomass and NPP, using data from a model system based on Brassica plants and butterfly larvae.

**Pre-Lab: Thinking through the processes**

1. Label the gross primary productivity (GPP), net primary productivity (NPP), and the secondary productivity (SP) on the diagrams below. Each term will be placed on an arrow.





1. Explain why you placed each term where you did on the diagrams.

**Part I: Estimating Net Primary Productivity (NPP) of Fast Plants**

Primary productivity is a rate — energy captured by photosynthetic organisms in a given area per unit of time. Based on the second law of thermodynamics, when energy is converted from one form to another (ex: during the reactions of cell respiration), some energy will be lost as heat.

In terrestrial ecosystems, productivity (or energy capture) is generally estimated by the change in biomass of plants produced over a specific time period. Measuring biomass or changes in biomass is relatively straightforward: simply mass the organism(s) on an appropriate scale and record the mass over various time intervals. The complicating factor is that a large percentage of the mass of a living organism is water — not the energy-rich organic compounds of biomass. Therefore, to determine the biomass at a particular point in time accurately, you must dry the organism. Obviously, this creates a problem if you wish to take multiple measurements on the same living organism.

**Procedures: Using Sample Data to estimate NPP for Fast Plants**

***Note: For all data tables, include units (grams for mass and kcal for energy) and round to the nearest hundredth where necessary***

To determine the amount of light energy stored as biomass within plants (i.e. the net primary productivity), a team of students started 40 Wisconsin Fast Plants from seed. After growing them for 7 days under a regimen of 24 hours of light a day, the team randomly selected 10 plants. The plants were carefully pulled, with their roots.

1. The team then took the 10 plants and placed them in a drying oven at 200°C for 24 hours. They then found the dry mass of the 10 plants. Fill in this value in **Row A** of Data Table #1 for the 7 day plants.

Dry mass of 10 plants (Day 7) = 7.6g

1. The team pulled 10 different plants on Day 14 and 10 different plants on Day 21. Use the data they obtained to fill in **Row A** of Data Table #1 for the 14 day plants and the 21 day plants

Dry mass of 10 plants (Day 14) = 15.1g

Dry mass of 10 plants (Day 21) = 25.3g

1. For **Row B** of Data Table #1, you will be converting this measurement of biomass (i.e. dry mass) to a measurement of energy in kilocalories (kcal). We are going to assume that every gram of biomass represents 4.35 kcal of energy. Therefore, you can complete the following calculation to convert from grams of biomass to kcal of energy…

More simply, you can take 4.35 and multiply it by the dry mass found in Row A.

1. For **Row C** of Data Table #1, you will be determining the NPP per plant. You will need to take the NPP for 10 plants from Row B and divide this by the number of plants in the sample (i.e. 10 plants).
2. For **Row D** of Data Table #1**,** you will be determining the NPP per plant per day. You will need to take the NPP per plant from Row C and divide this by the number of days (i.e. 7, 14, or 21 days).

***Data Table #1 (Just your team)***

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Row** | **Value** | **Show your work!** | **7 Day Plants** | **14 Day Plants** | **21 Day Plants** |
| A | Dry Mass for the 10 plants | Given, no calculation needed |  |  |  |
| B | Energy Content (NPP) for the 10 plants over 7, 14, or 21 days |  |  |  |  |
| C | Energy content (NPP) per plant over 7, 14, or 21 days |  |  |  |  |
| D | Energy content (NPP) per day per plant |  |  |  |  |

Complete the Data Table #2 for this exercise. Your team’s data for NPP per plant per day (found in **Row D**) will go in the empty column as “Team 1.” Find the average NPP per plant per day for 7, 14, and 21 days, and record these average values in the “class mean” column on the right.

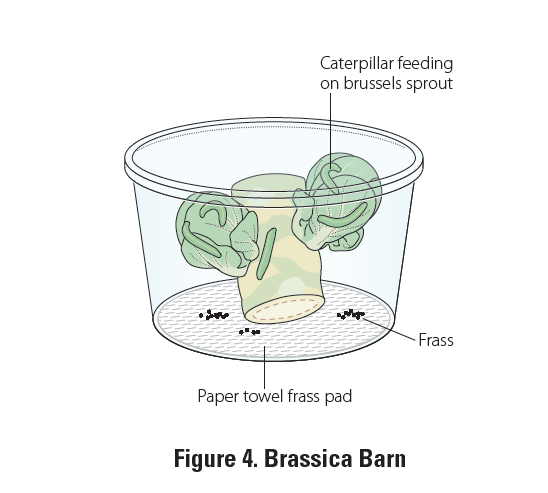
***Data Table #2 (Class Averages)***

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Time (days)** | **Team 1** | **Team 2** | **Team 3** | **Team 4** | **Team 5** | **Team 6** | **Class Mean** |
| 7 |  | 0.43 | 0.47 | 0.44 | 0.46 | 0.44 |  |
| 14 |  | 0.49 | 0.51 | 0.50 | 0.49 | 0.52 |  |
| 21 |  | 0.55 | 0.54 | 0.55 | 0.53 | 0.51 |  |

**Part II. A New Experiment! Calculating NPP for Brussels Sprouts and SP for Cabbage Butterfly Larvae.**

In this part of the lab, teams used Brussels Sprouts as their producers and cabbage butterfly larvae as the primary consumers.

The following diagram shows energy flow into and out of a primary consumer (the larvae). The amount of biomass in the larvae represents the secondary productivity, or the amount of energy from their food (the Brussels sprouts) they are able to convert to chemical energy in their own tissues.



1. The team of students made a “brassica barn” by placing Brussels sprouts in an aerated container with 10 caterpillar larvae that were 12 days old. Before assembling the barn, students weighted both the sprouts and the larvae. Fill in the wet mass of the Brussels Sprouts for Day #1 in **Row A** of Data Table #3**.**

Wet mass of Brussels sprouts= 30g

Wet mass of 10 larvae = 0.3g

1. After 3 days, the team re-weighed the sprouts and larvae. Fill in the wet mass of the Brussels Sprouts for Day #3 in **Row A** of Data Table #3**.**

Wet mass of Brussels sprouts = 11g

Wet mass of 10 larvae = 1.8g

1. To fill in the Change from Day 1 to Day 3 in the wet mass of the Brussels sprouts (**Row A** of Data Table #3), use the following calculation. The value you obtain will be negative which indicates that the mass of the Brussels Sprouts has decreased due to larvae feeding. Although this value is negative, please record it as a positive value to use in further math calculations.

Change in Wet Mass = Wet Mass on Day 3 – Wet Mass on Day 1

1. A drying oven was then used to find the biomass of the larvae, the remaining Brussels sprouts, and the frass (i.e. larvae poop!).

Dry mass of Brussels sprouts = 2.2g

Dry mass of 10 larvae = 0.27g

Dry mass of frass from larvae = 0.5g

Use the dry mass given for the Brussels sprouts on Day 3 above and the wet mass for the Brussels sprouts on Day 3 (from **Row A**) to calculate the plant % biomass (as a decimal) by using the following calculation. This value will be used for Day 1 and Day 3 **(Row B** of Data Table #3**)** because we cannot take the dry mass of the Brussels sprouts on Day 1 without killing them.

Plant % Biomass (as a decimal) = Dry Mass on Day 3 / Wet Mass on Day 3

1. To convert from units of mass to units of energy for the NPP on Day 1 and Day 3 **(Row C** of Data Table #3**)**, use the following calculation. Remember, we are assuming that there are 4.35 kcal of energy per 1 gram of biomass.

Plant energy (NPP) (in kcal) = Wet mass x % biomass x 4.35 kcal

1. To fill in the Change from Day 1 to Day 3 column for **Row C**, use the following calculation. This represents the kcal of plant material consumed by all 10 larvae over the three days.

***Note: You will calculate a negative value, but please record it in the data table as a positive value***

Change in Plant Energy (in kcal) = Energy Consumed by 10 Larvae on Day 3 (in kcal) = Plant Energy (NPP) on Day 3 – Plant Energy on Day 1 (NPP)

1. To determine the Plant Energy Consumed Per Larvae (**Row D** of Data Table #3) over the three days, take the value you just calculated (last column in **Row C**)and divide by the number of larvae (i.e. 10 larvae).

***Data Table #3 (Energy in Brussel Sprouts)***

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Row** | **Value** | **Show Your Work** | **Day 1** | **Day 3** | **Change from Day 1 to Day 3** |
| A | Wet mass of Brussels sprouts (in grams) | Given, no calculation needed |  |  |  |
| B | Plant % Biomass (calculate for Day 3) |  | Same as day 3 |  | N/A |
| C | Plant energy (NPP) (in kcal) |  |  |  |  |
| D | Plant energy consumed per larvae (in kcal) |  | N/A | N/A |  |

1. Fill in the wet mass of the larvae on Days 1 and 3 (see data on page 4) in **Row A** of Data Table #4**.**
2. To fill in the Change from Day 1 to Day 3 in the wet mass of the larvae (**Row A** of Data Table #4), use the following calculation. This represents the wet mass gained by all 10 larvae as a result of eating the Brussels sprouts.

Change in Wet Mass = Wet Mass on Day 3 – Wet Mass on Day 1

1. Use the dry mass given for the larvae on Day 3 on Page 4 and the wet mass for the larvae on Day 3 (from **Row A**) to calculate the larvae % biomass (as a decimal) by using the following calculation. This value will be used for Day 1 and Day 3 **(Row B** of Data Table #4**)** because we cannot take the dry mass of larvae on Day 1 without killing them.

Larvae % Biomass (as a decimal) = Dry Mass on Day 3 / Wet Mass on Day 3

1. To convert from units of mass to units of energy for the larvae energy storage **(Row C** of Data Table #4**)**, use the following calculation. For larvae, we use a different conversion factor. There are 5.5 kcal energy stored for each gram of biomass in a larvae.

Larvae Energy Storage (in kcal) = Wet mass x % biomass x 5.5 kcal

1. To fill in the Change from Day 1 to Day 3 column for **Row C** of Data Table #4, use the following calculation. This represents the change in kcal of energy stored in the 10 larvae as a result of eating the Brussels sprouts from Day 1 to Day 3.

Change in Larvae Energy Storage (in kcal) = Energy Stored by 10 Larvae on Day 3 – Energy Stored by 10 Larvae on Day 1

1. To determine the change in larvae energy storage per larvae (**Row D** of Data Table #4) over the three days, take the value you just calculated (last column in **Row C**)and divide by the number of larvae (i.e. 10 larvae).

***Data Table #4 (Energy in Butterfly Larvae)***

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Row** | **Value** | **Show Your Work** | **Day 1** | **Day 3** | **Change from Day 1 to Day 3** |
| A | Wet mass of 10 larvae (in grams) |  |  |  |  |
| B | Larvae % biomass |  | Same as day 3 |  | N/A |
| C | Larvae Energy Storage (in kcal) |  |  |  |  |
| D | Change in Larvae Energy Storage Per Individual |  | N/A | N/A |  |

1. Record the dry mass of the frass (i.e. larvae poop) on Day 3 (data from Page 4) in **Row A** of Data Table #5**.**

1. Convert the dry mass of the frass from grams to kcal, a unit of energy using the calculation given below. Record this value in **Row B** of Data Table #5. This will tell you how much energy is stored in the frass of all 10 larvae. Note that there is a different conversion factor for frass than larvae tissue or Brussels sprout tissue. Every gram of dry frass contains 4.75 kcal of energy.

Frass Energy Storage (in kcal) = Dry mass of frass x 4.75 kcal

1. Calculate the energy stored in one larvae’s frass, take the number you just calculated in **Row B** of Data Table #5 and divide by 10 (for 10 larvae). Record this value in **Row C** ofData Table #5.

***Data Table #5 (Energy in Frass)***

|  |  |  |  |
| --- | --- | --- | --- |
| **Row** | **Value** | **Show Your Work** | **Day 3** |
| A | Dry mass of frass from 10 larvae (in grams) | Value Given |  |
| B | Frass energy (in kcal) |  |  |
| C | Energy of frass from 1 larvae? (in kcal) |  |  |

**Follow-Up Questions:** Answer each questions given below thoroughly and accurately and in complete sentences.

1. What does the data from Data Tables #1 and 2 allow us to conclude about the effect of additional growth time on the net primary productivity of plants.
2. Why can’t we use the**wet mass** of the Brussels sprouts to calculate the NPP in units of energy (kcal)?
3. For Data Table #4, what do Rows C and D represent? You are choosing between GPP, NPP, and SP. You must explain your choice.
4. Calculate the energy lost by the primary consumer (the larvae) to respiration. You should calculate this value using the plant energy consumed per larvae, SP per larvae, and frass energy storage per larvae. Use the information in the second diagram on page 1 to help you determine how to calculate this value. Then, explain why you calculated the value in the way you did.